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ASCOCHYTA CLEMATIDINA, THE CAUSE OF STEM-ROT AND LEAF-SPOT OF CLEMATIS

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INTRODUCTION

The sudden dying of clematis plants has been known for many years, and there has been much speculation as to its cause and prevention. Apparently the disease occurs in both Europe and America wherever the large-flowered kinds of clematis are grown extensively. From published accounts it is clear that the various writers had in mind the same disease, though they ascribed it to different causes. In 1884 Arthur (1) [1] studied a clematis stem-rot which he suspected of being due to the fungus *Phoma clematidis* Sacc. Trelease (16), Comstock (3), Klebahn (7), and others have considered nematodes as the causal agent. In specimens received from Klebahn, Ritzema Bos (2) found nonparasitic nematodes, while in material of his own collection he found the larvæ of a fly, *Phytomyza affinis*, and a species of Pleospora. Prillieux and Delacroix (9) and Morel (8) believed the disease to be of bacterial origin. Sorauer (13) reports a gall-like formation on the stem of *Clematis jackmanni* near the surface of the soil and attributes the death of the affected plants to *Gloeosporium clematidis*. Green (5, p. 284–285) has reported the relative susceptibility of a few varieties of clematis which he grew, but he did not attempt to ascertain the cause of the disease. Except for a preliminary abstract by the writer (4), the primary cause of the clematis disease has heretofore been unknown.

DESCRIPTION OF THE DISEASE

The clematis disease manifests itself differently on the various species and hybrids. On hybrids grown in the field it is a stem-rot, while in the greenhouse, where the cuttings are propagated, it is a leaf-spot as well as a stem-rot. On *Clematis paniculata* the disease takes both forms.

C. paniculata, a type species, is propagated from seed [2] and when grown in uninfected cold frames or greenhouses remains free from disease. Such seedlings are either potted or placed in beds, where they are planted about an inch apart in rows 4 inches apart. In the fall, when these plants

[1] Reference is made by number to "Literature cited," p. 341–342.

[2] For description of general methods of propagation and of the various species of clematis see the following: Bailey, L. H., ed. Cyclopedia of American Horticulture. ed. 7, v. 1, p. 327–333, fig. 485–492. 1910.

Le Bêle, Jules. The clematises. *In* Garden, v. 53, no. 1388, p. 544–548, illus.; v. 54, no. 1391, p. 39–40, no. 1395, p. 127; no. 1396, p. 138; no. 1399, p. 200–201; no. 1401, p. 240–241. 1898. *Translated from* Bul. Soc. Hort. Sarthe, 1896.

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have made a growth of 8 to 10 inches, the leaf-spot may make its appearance and be thus carried over the winter on the dead leaves or in lesions formed on the vines. If these plants are left in the beds a second season, the fungus may make its appearance early in spring and increase until by midsummer no vine is wholly free from disease. The leaf-spot may first appear either as a mere dot or as a water-soaked area. With the advent of moist warm weather the former usually leads to the latter. On drying the water-soaked spot becomes tan-colored with a red margin. Plate L shows the general appearance of the disease on *C. paniculata*. The older leaves are badly diseased or dead, and the fungus has grown down the petiole to the node, where in time the vine may become girdled. The younger leaves show the early stages of the leaf-spot. The stem shows the lesions, reddish in color, formed at the nodes and on the internodes. Later these take on a gray color. Plate LI illustrates a group of leaves of *C. paniculata* with spots that are zonate, owing to the unequal growth of the fungus under the influence of changes in temperature. The newly formed spot has a dark margin of red tissue and a lighter center. Pycnidia are produced on the diseased leaves. Succulent growing tissues succumb more readily to the disease than do the woody stems. In the latter it may require a month for the fungus to pass a node. Plate LII, figure 1, shows a portion of a vine of *C. paniculata* 44 inches long on which the lower leaves were wilted, while the distal ones were still turgid. The fungus entered through the stub *a*. It girdled the stem and disintegrated the upper roots, leaving the central cylinder as the only means of communication with the healthy roots below. Pure cultures of *Ascochyta clematidina* were obtained from the boundaries of the lesion. Pycnidia were formed on the stem above the ground. In other cases pycnidia have been found on the epidermis, while the tissues underneath were healthy.

Some of the large-flowered kinds of clematis are grown from seed, but in America the majority of those cultivated are hybrids. They are propagated from cuttings taken from rapid-growing, disease-free vines. The cuttings are made in May or June and consist of a single node with the attached leaves and the internode below. They are placed in moist sand and exposed to bottom heat or else grown in forcing frames. In forcing frames the humidity and temperature are usually higher than is found in the average greenhouse. Under these conditions, if the spores are present, a leaf-spot may be formed, and the entire cutting may be killed or the fungus may be halted at the node. The fungus that has been checked may again become active when the cuttings are potted and placed in the greenhouse, or new infections may take place on the leaves. In the fall some of the plants are placed in storage, while others are kept over winter in the greenhouse and the tops used for cuttings. In the following spring both lots are transplanted into the open field and, unlike *C. paniculata*, are not allowed to trail on the ground. Experience has

taught the nurseryman that supported vines, owing to the better ventilation they receive, do not die as readily as those left on the ground. They make a vigorous growth, and yet when about to bloom they may suddenly die. It is at this stage that the disease first attracts the attention of the nurseryman, though in reality it was on the plants while they were still in the greenhouse and was there overlooked. Plate LIII, figure 1, shows a plant free from leaf-spot, yet girdled by the fungus lurking in the stub *a*, which in ordinary practice is not removed. Plate LIII, figure 2, is a reproduction of another vine of *C. jackmanni* that had many pycnidia of *A. clematidina* on the old stub. After the removal of this stub some of the discolored tissue still remained. The new shoot formed is wilting, and the split stem shows discolored fibrovascular bundles from which *A. clematidina* was isolated. In advanced stages the roots may disintegrate similarly to that shown in Plate LII, figure 1. The spots on the leaves of *C. jackmanni* resemble those found on *C. paniculata*, *C. recta*, and *C. virginiana*.

ISOLATION OF THE CAUSAL FUNGUS

By previous writers the dying of clematis plants has been assigned to various factors, but none have discovered the primary cause. The dying of the leaves owing to lack of light, the breaking of the vine by strong winds, and injury by nematodes are factors that have been eliminated as primary agencies, while the constant association of *A. clematidina* points to it as the causal organism. The fungus can be readily isolated by the poured-plate method, using the spores from a crushed pycnidium, by the use of sterile leaf tissues, or by the use of free-hand sections of diseased material. The last-named method consists in making free-hand sections under as sterile conditions as possible by sterilizing the outer tissue and the instruments. If such sections show mycelium they are transferred to sterile media. Some have maintained that no mycelium can be seen in the decayed tissue, but the writer has observed in the tissues 3 to 5 mm. from the boundaries of the lesions mycelium which in plate cultures proved to be that of the causal organism, *A. clematidina*.

A. clematidina grows well on the media generally used in the laboratory. It grows at about the same rate on nutrient glucose agar, oatmeal agar, bean pods or stems, moist oats, and corn meal, producing pycnidia in five to seven days. These pycnidia may show a pink tinge at first and later turn brown. The fungus grows less vigorously on corn-meal agar, potato agar, starch agar, sugar-beet plugs, apple twigs, and sterile raw carrot. Oatmeal and starch agar are at first turned green, but later take on a brown color. On starch agar the mycelium penetrates the medium and forms chlamydospores, as shown in Plate LII, figure 1. These are thick-walled, green-brown bodies filled with oil globules. When placed in water, they germinate readily.

INOCULATION EXPERIMENTS

To prove the pathogenicity of *A. clematidina*, mycelium from pure cultures was inoculated into stems of *C. paniculata* and *C. jackmanni*. In all cases lesions were produced, while the checks remained normal. From such lesions the fungus was reisolated, and, when again inoculated into either host, typical lesions were produced. In all, four sets of inoculation experiments were carried out at various times, making from 3 to 10 inoculations on each of 32 plants. Inoculations on succulent stems caused the vines to wilt in four days, while in one case an inoculation on a woody vine 6 mm. in diameter required 47 days to kill the plant. Pycnidia were produced on all lesions.

Plants of *C. paniculata* were sprayed with sterile water containing spores of *A. clematidina* and then kept under bell jars for two days. On the third day the leaves showed water-soaked spots of various sizes, while the checks, which had been sprayed with sterile water, remained free from disease. To test the effect of temperature on infection, two plants were sprayed with the same spore-laden water and then subjected to different temperatures: 23° C. and 10° C. At the end of five days the plant kept at 23° showed 45 leaf spots, while the plant kept at 10° showed but 1 spot.

Spores placed on the lower surface of the leaves produced more spots than those placed on the upper surface. Typical lesions were also produced on the roots by inoculating them with the mycelium from a pure culture.

The *A. clematidina* isolated from *C. paniculata* was inoculated into growing stems of bean, pea, muskmelon, pumpkin; into stems, petioles, and fruits of eggplant (var. Black Beauty); and into the young shoots of elm. In all cases negative results were obtained. On most of these plants pycnidia were produced on the tissues killed in making the wound, but in no case did the mycelium penetrate the healthy tissues and form a lesion.

TAXONOMY OF THE FUNGUS

Arthur (1) observed a species of Phoma, possibly *P. clematidis*, on clematis, but on consulting the original notes made by him it is clear that he had a fungus different from that found by the writer. On but one occasion has *Phoma* sp. been found and that was a saprophyte on the leaf of *C. paniculata*. It was isolated in pure culture, the mycelium inoculated into the stems, and the spores sprayed on leaves, but in no case were lesions or leaf-spots produced.

Saccardo (11) notes *A. clematidina*, *A. vitalbae*, *A. indusiata*, and *A. davidiana* as occurring on various species of clematis, and their chief point of difference is in the size of the spores. The writer has examined the specimens of *A. clematidina* Thümen on *C. virginiana* collected by Mr. J. J. Davis in Wisconsin and distributed in Fungi Columbiani No.

2503; also those of *A. indusiata* Bres. on *C. recta* in Krieger's Fungi Saxonici No. 1189. In both, the spots resemble those found on *C. paniculata* and *C. jackmanni*. In the former the spores are cylindrical 1-septate and hyaline. They measure 8 to 12 by 3.2μ, the average dimensions being 9.5 by 3.2μ. The spores of the latter species are hyaline to honey-colored, somewhat constricted, and measure 12 to 22 by 6.3μ, with an average of 19 by 6μ.

The writer has repeatedly examined the species of Ascochyta on clematis and found it quite variable. The chief difference is in the spores, though sometimes the pycnidia are more deeply immersed than at other times. Plate LIV, figure 1, shows a pycnidium in the leaf tissues of *C. paniculata*. The spores vary in length from 6 to 28μ and in width from 3 to 6μ, but generally they are about 9 to 13 by 3 to 4μ. Plate LII, figure 3, shows the typical spores. The spores are either 1– or 2–celled, rarely 3–celled. Some leaves of *C. jackmanni* collected in the fall of 1914 showed pycnidia having spores as long as 28μ and averaging 18 by 5.7μ. Inoculations with material from cultures obtained by the isolation of single spores showed that this fungus was the same as that usually encountered. The various differences in color shown by the spores disappear when the spores are plated out under control conditions. Considering the variability of the fungus found by the writer, any of the descriptions given for the different species of Ascochyta described on clematis would in general apply to it. Hence, the name selected is the oldest one, *Ascochyta clematidina* Thümen, the description of which is here emended as follows:

Ascochyta clematidina (Thümen).

Ascochyta clematidina Thümen, Pilzfl. Sibir. n. 619, 1884, *in* Sacc. Syll. Fung., v. 3, p. 396.

On stems and foliage; spots circular, zonate to indefinite; pycnidia (on leaves mostly epigenous, sometimes hypogenous) tan to dark brown, scattered to gregarious, globose to subovoid, immersed, then erumpent, ostiolate, averaging 120μ in diameter; spores variable, subellipsoidal to cylindrical, 1- or 2-celled, septa more or less medial, sometimes constricted, hyaline to dilute honey or olive color, often guttulate, 6 to 28 by 3 to 6.4μ, usually 9 to 13 by 3 to 4μ; exuded spore mass honey-colored, sometimes pink.

On living leaves and stems of *Clematis paniculata, C. virginiana*, and the hybrids *C. hendersoni, C. henryi, C. jackmanni, C. ramona, C. Duchess of Edinburg, C. Mme. Baron Veillard*, and *C. Mad. Èdouard André*. According to Von Thümen, it occurs also on living leaves of *C. glauca*. As yet no perfect form of *A. clematidina* has positively been found.

CONTROL EXPERIMENTS IN 1913

In 1913 some 2-year-old plants of *C. paniculata* that had made a dense, matted growth of tangled vines were badly diseased, while a bed of seedlings next to them was free from disease. In an attempt to save the 2-year-old plants, they were cut back to a length of 4 to 6 inches and then sprayed with Bordeaux mixture on July 21. A small area was left unpruned and unsprayed as a check. By October 17 the seedlings,

which had made a growth of 8 to 10 inches, showed an occasional leaf spot. The pruned-and-sprayed plot produced an excellent growth, but had some leaf-spot and a few girdled vines. The check showed many dead plants, and none of the living ones were entirely free from disease.

CONTROL EXPERIMENTS IN 1914

A writer in Garden (10) states that Bordeaux mixture, when applied to diseased clematis plants, was of no benefit in checking the disease. In 1914, spraying experiments were carried out by the writer on 18 rows (about 300 feet long) of plants of *C. jackmanni*, half of which were sprayed with Bordeaux mixture (4–4–50 formula), while the others were left as checks. Four of these, two checks and two sprayed rows, were pruned on June 12 and 25 in such a manner as to remove the dead stubs of the previous year. Plants from which all of the discolored tissue could not be removed without injury to the entire vine were marked with tags. The rows receiving Bordeaux mixture were sprayed every two weeks. The final examination was made on October 19. No difference could be seen between the sprayed and the check rows either in the amount of leaf spot or the number of dead plants. The same held true for the pruned and unpruned rows. However, there was but little leaf-spot, and it was observed that the dead plants in the pruned rows were invariably plants that had been tagged. No doubt the pruning was done too late in the season to be of any benefit. Sulphur dusted on cuttings in the forcing frames did not check the disease. Plants in the greenhouse sprayed with soap-and-sulphur mixture so as to cover the leaves with a thin film were healthier than the unsprayed plants. These, however, were not carried through the second season, and hence the ultimate results are unknown.

Two long, narrow beds of *C. paniculata* were utilized for spraying and dusting experiments in 1914. Bed 1 consisted of yearling plants untreated in 1913. Bed 2 contained 2-year-old plants pruned and sprayed with Bordeaux mixture in 1913. Both beds were divided into plots 6 by 25 feet in size.

Two plots in each bed were sprayed with Bordeaux mixture six times at intervals of two weeks from May 15 to August 8. On the same dates one plot in each bed was sprayed with a soap-and-sulphur mixture composed of 1 pound of soap, 6 pounds of sulphur, and 15 gallons of water. Two and one-half gallons of the mixture, containing 1 pound of sulphur, were used on each plot at each application. On two plots in bed 1 and one plot in bed 2 the plants were dusted six times with sulphur, using 1 pound to the plot at each application. The remaining eight plots (three in bed 1 and five in bed 2) were left untreated for checks.

As the season advanced, the virulence of the disease increased, becoming quite severe on all three check plots in bed 1 and one check plot in bed

2. On August 8 some of the plots were pruned, thus terminating the main experiment. The effect of the different kinds of treatment up to August 8 is shown in Table I.

TABLE I.—*Results of an experiment on the control of leaf-spot and stem-rot of Clematis paniculata*

Bed No. 1.			Bed No. 2.		
Plot No.	Treatment.	Percentage of plants free from disease.	Plot No.	Treatment.	Percentage of plants free from disease.
1	Bordeaux mixture	75	9	Bordeaux mixture	60
2	Check	2	10	Check	2
3	Bordeaux mixture	80	11	Sulphur	70
4	Check	10	12	Check	45
5	Sulphur	80	13	Soap and sulphur	100
6	Soap and sulphur	100	14	Check	85
7	Check	10	15	....do	85
8	Sulphur	65	16	....do	85
			17	Bordeaux mixture	95

The results are more uniform in bed 1 than in bed 2. This may be due to the treatment of bed 2 the previous year. That there was more disease in plots 9 and 10 than in the other plots of bed 2 may be accounted for by the fact that these two plots were used as checks in 1913, and hence were neither pruned nor sprayed in that year. Plots sprayed with the soap-and-sulphur mixture remained free from leaf-spot and lesions on the stems; hence, their condition is rated at 100 per cent. In rating the other plots the amount of leaf-spot, the number of lesions, and number of girdled plants have all been considered.

On the plots 1, 3, and 17, which were sprayed with Bordeaux mixture and which were not pruned on August 8, the spraying was continued to the end of the season. Check plots 4, 14, and 16 also were left unpruned. On October 19, when the final examination of these plots was made, it was found that in plots 1 and 3 the leaves on the new growth were disease-free and that there was but an occasional dead vine. On check plot 4 half of the newly formed leaves were diseased, and about one-third of the vines were dead. Plots 16 and 17 showed about the same amount of leaf-spot, only an occasional spot. The former, however, showed more lesions on the stems than the latter. Check plots 2, 7, 10, and 12, which had been pruned back to a length of 4 to 6 inches and then given one application of Bordeaux mixture, had but little disease as compared with plot 4, which had received no treatment whatsoever.

INJURIOUS EFFECTS OF SULPHUR ON CLEMATIS PANICULATA

The promising results obtained by Smith (12) in dusting asparagus with sulphur for the control of rust led the writer to try sulphur in con-

trolling the fungus on clematis. Up to August 8 the results were satisfactory, and no injury was observed. Soon after the pruning of August 8 there were several hot, dry days followed by a period of rainy weather, during which water accumulated at the end of bed 1. Up to the end of the season only one plant in plot 8 had sent forth a new shoot. The other vines were dead, and the stems at the surface of the ground for about an inch were discolored. A particle of soil placed on the tongue had an acid taste. According to a test made by Mr. R. F. Keeler, 1 gm. of this soil is equivalent to 0.5 c. c. of 0.1 *N* acid, while soil from the adjoining check plot 7 was neutral. In check plot 7 a few vines died, owing to the lack of drainage, but it seems apparent that in the other cases the injury was caused by sulphur that had washed from the foliage and had accumulated in the upper layer of soil. As the season advanced, sulphur injury was observed in the other treated plots, but in these cases the injury was localized in areas not larger than 2 feet in diameter. The injury began to show on the plots sprayed with the soap-and-sulphur mixture after nine applications had been made, while in the plots dusted with sulphur it appeared after six applications had been made.

SOAP AND SULPHUR AS A SPRAY MIXTURE

A mixture of about 1 pound of laundry soap and 6 pounds of sulphur in 15 gallons of water was in common use as a greenhouse spray at the nursery where the spraying experiments were conducted. It was used with success in the control of leaf-blotch, *Diplocarpon rosae* Wolf, on susceptible varieties of roses grown in the forcing houses. Halsted and Kelsey (6) used Ivory soap at the rate of 1 ounce to 4 gallons of water for spraying *Phlox drummondii* and the common verbena attacked by powdery mildew and were able to check it. Another (15) has shown that soap at the rate of 1 ounce to 1 gallon of water controlled the mildew and aphids of roses. R. E. Smith (12) recommended that, in the absence of dew, whale-oil soap be sprayed on asparagus tops to hold the sulphur that is to be dusted over them for the control of the rust. Spieckermann (14) has shown that weak solutions of soap have a nutritive value and can be assimilated by the higher fungi.

In order to test the toxic effect of soap, mycelium of *A. clematidina* was transferred to Petri dishes containing soap agar of different strengths—viz, 2 per cent agar containing alkali-free Ivory soap in the proportion of 1 pound to 5, 10, 15, 20, and 40 gallons of the medium. Fifteen c. c. of such media were placed in each Petri dish. When the fungus became established, the diameter of the culture was measured daily, and the rate of growth was considered as a measurement for toxicity. Cultures on 2 per cent agar and nutrient-glucose agar served as checks. Table II gives the averages of growth of four or five cultures on each medium grown under the same conditions at room temperature.

TABLE II.—*Summary of the data on the toxic effect of soap agar of various strengths on Ascochyta clematidina*

Culture medium.	Number of cultures.	Average diameter of cultures after growth for—									
		3 days.	5 days.	7 days.	9 days.	11 days.	13 days.	15 days.	17 days.	20 days.	23 days.
		Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Soap agar (1 lb. to 5 gals.)	5	0	0	0	0	0	0	0	0	0	0
Soap agar (1 lb. to 10 gals.)	5	0	0	0	0	0	0	0	0	0	0
Soap agar (1 lb. to 15 gals.)	4	0	7	9	11	15	18	20	22	25	28
Soap agar (1 lb. to 20 gals.)	5	0	11	15	19	23	26	30	34	39	44
Soap agar (1 lb. to 40 gals.)	4	8	20	25	32	40	44	50	56	67	73
Check, 2 per cent agar	5	10	21	29	40	51	61	70	77	85	.....
Check, nutrient-glucose agar	5	15	29	38	48	60	69	77	.....	.....	.....

Plate LIV, figure 2, shows a culture of *A. clematidina* on soap agar. The concentric ring or oily film about the culture may be 2 to 7 mm. wide. Upon the drying of the medium, crystals of stearic acid are seen only in this region, indicating that an active principle given off by the fungus liberated the fatty acid. The culture shows a green discoloration, which is due to the formation of brown-green, thick-walled chlamydospores. These bodies, as well as the mycelium, are filled with oil globules, while none are found in the 2 per cent agar. These cultural experiments indicate that soap at the strengths in which it is used as a contact insecticide has in itself fungicidal value, as well as being a means of adhesion or suspension for other materials.

METHODS OF CONTROLLING THE FUNGUS

The suggestions here given for controlling *A. clematidina* are based upon the observations and experiments made in the last three years. Greater success can be attained by changing the methods of culture than by spraying. Long experience has taught the nurseryman that there is less disease when the hybrids are supported while growing in the field or in the greenhouse than when they are permitted to trail on the ground. This holds true also for *C. paniculata*, but its selling price does not warrant so much expense for labor. This can be overcome by transplanting the plants from the beds to the open field after the first year, placing them far enough apart to prevent matting. Spraying is beneficial to such plants, but before making such applications it is advisable to remove all diseased leaves and dead vines. Plants so treated are disease-free in the fall. If seedlings are grown in a greenhouse where clematis has never been grown before and are kept away from older diseased beds, they will

remain disease-free. The fungus can live as a saprophyte on dead vines kept out of doors in baskets, and under such conditions it has lived over two winters, producing pycnidia and viable spores in abundance. This indicates that the same beds should not be used for clematis in successive years.

On hybrids the disease is primarily a greenhouse trouble and can be overcome by the use of cuttings made from healthy plants. A light spraying with the soap-and-sulphur mixture has proved satisfactory in the greenhouse. It could readily be applied also in the forcing frames. Diseased leaves or stubs should be removed as soon as discovered so as to prevent the fungus becoming established in the tissues.

The retail purchaser of clematis can prevent the dying of plants by taking proper simple precautions. The plants should be placed in good soil, well drained and on a sunny exposure. As soon as the new shoots have formed the old vine tissue should be carefully cut away close to the new shoots, removing all traces of the brown, discolored wood in which the fungus is to be found. Proper ventilation is obtained by training the plants to a strong trellis.

SUMMARY

(1) The stem-rot and leaf-spot of clematis is caused by the fungus *Ascochyta clematidina* (Thümen.).

(2) The plants are killed by the growth of the fungus down the petiole into the stems, thus girdling the plant at the node. The stem may be girdled also by the lesions anywhere on the internodes. Dead stubs left on the vines are a means of holding the disease over a period of time. New shoots may be formed below the girdled region, but the downward progress of the fungus ultimately kills the plant if the diseased tissue is not removed.

(3) Overwintering out of doors does not kill the fungus in cultures or on dead vines. Whenever the temperature permits, the fungus resumes its growth.

(4) The fungus is readily isolated and grows well on the media generally employed in the laboratory.

(5) The disease has been successfully produced by inoculating *C. paniculata* and *C. jackmanni* with the mycelium from pure cultures. The fungus has been reisolated from such inoculations, and with it lesions were again produced on other vines similarly treated.

(6) *A. clematidina* is not related to other common species of the genus Ascochyta, for inoculations made in growing stems of bean, pea, muskmelon, pumpkin, eggplant, and the young shoots of elm gave negative results.

(7) Spraying the plants with spores will produce the leaf-spot. More spots are produced when the spores are placed on the lower surface of

the leaf than on the upper. A temperature of 23° C. is more favorable for the production of the leaf-spot than a temperature of 10° C.

(8) The matting of the vines produces a condition most favorable for the spread of the disease. Ventilation can be obtained by supporting the vines or by planting them far enough apart to prevent matting.

(9) On the hybrids the disease can be controlled in the forcing frames or in the greenhouse by the use of sprays. In the field, the spraying of hybrids properly supported is of little benefit.

(10) On *C. paniculata* spraying with a fungicide checks the disease. In the field the removal of diseased leaves and vines before spraying is of practical value in controlling the disease.

(11) Sulphur dusted on *C. paniculata* in large quantities may cause injury.

(12) A mixture of 1 pound of laundry soap and 6 pounds of sulphur to 15 gallons of water, when sprayed on cuttings in the greenhouse or on *C. paniculata* growing in the beds, controlled the disease.

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PLATE L

Clematis paniculata: Portion of vine showing the general nature of the leaf-spot.

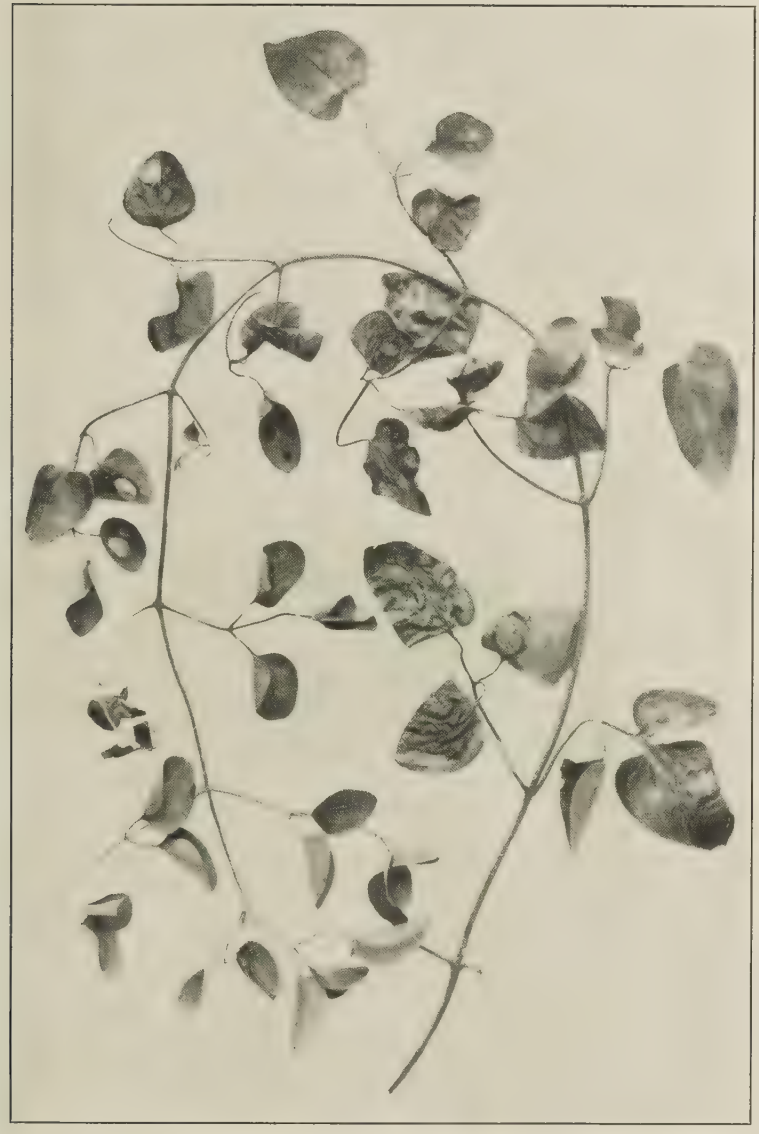


PLATE LI

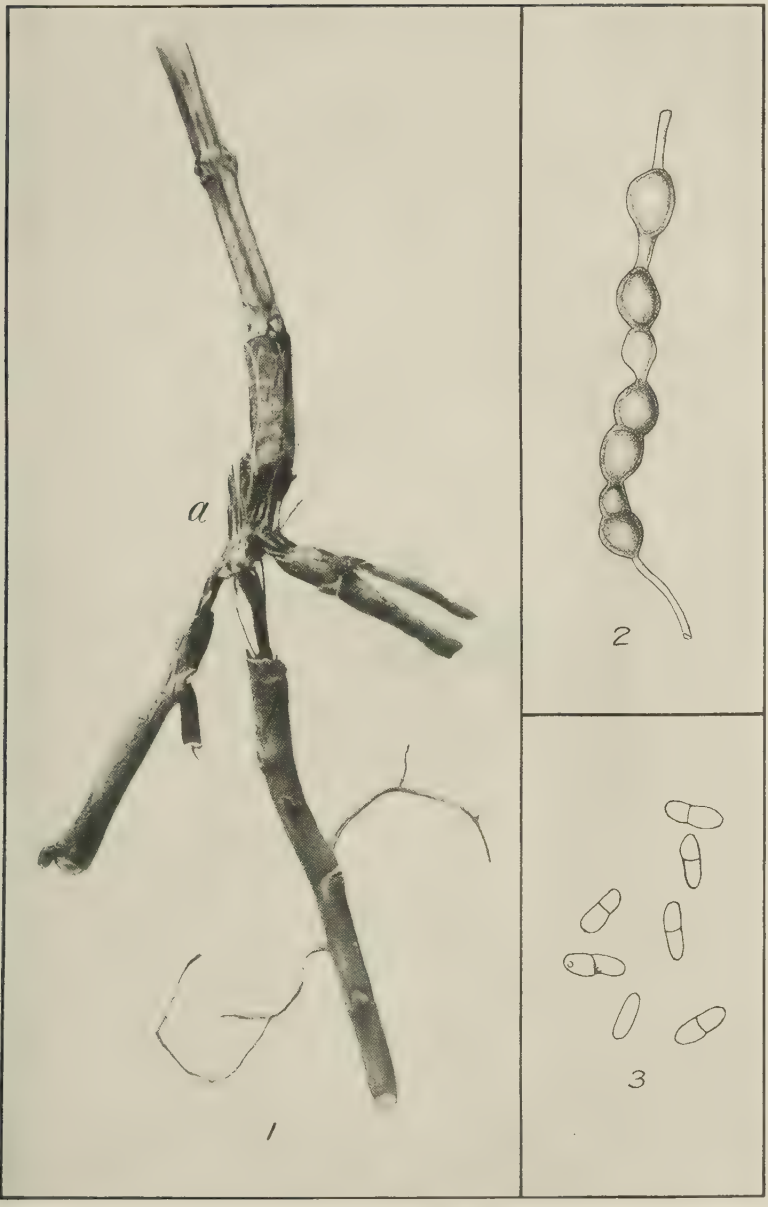
Clematis paniculata: Group of leaves enlarged to show the zonation and pycnidia of the spots. One leaf shows the newly formed spot, with its lighter center.

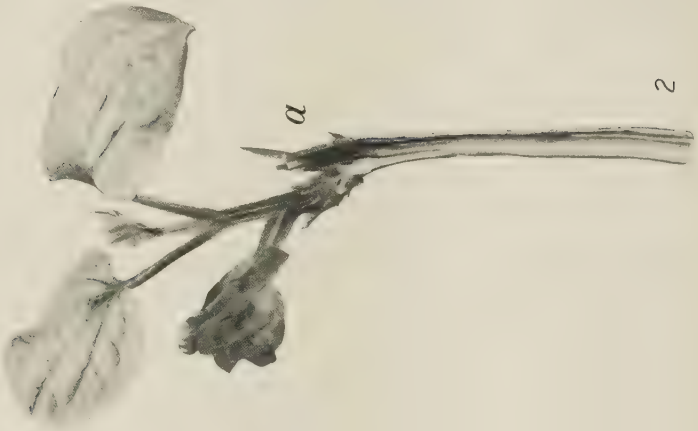
PLATE LII

Fig. 1.—*Clematis paniculata:* A portion of a vine 44 inches long that showed indications of wilting of the lower leaves while the distal leaves were still turgid. The fungus entered through the stub *a*. In the girdled region the parenchyma of the roots had disintegrated, leaving the central cylinder as the only means of communication with the healthy roots below. *Ascochyta clematidina* was isolated in pure cultures from the boundaries of the lesion.

Fig. 2.—*Ascochyta clematidina:* Chlamydospores as formed on starch agar.

Fig. 3.—*Ascochyta clematidina:* Camera-lucida drawing of spores.


a
1
2
3


a
2

a
b
1

PLATE LIII

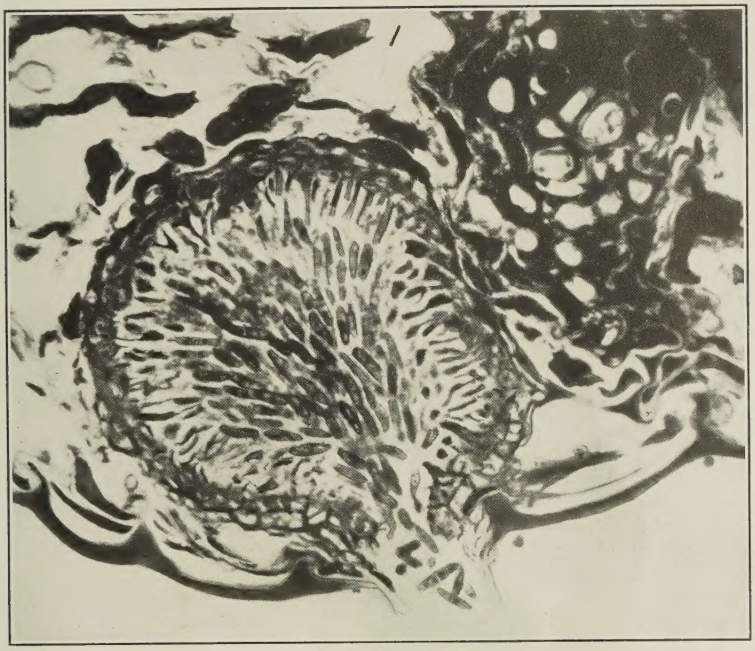
Fig. 1.—*Clematis jackmanni:* A vine free from leaf-spot that has been girdled by *Ascochyta clematidina* in the region of the previous year's stub *a*. A new shoot would have been sent forth from an active bud at *b*, but it would have soon died, for the fungus had discolored the vascular bundles beyond this point. The presence of the fungus was proved by isolating it from the discolored tissue.

Fig. 2.—*Clematis jackmanni:* Plant from which the diseased stub *a* was cut away without removing the discolored tissue. The leaves were free from leaf-spot and were drying. The split stem shows the discolored fibrovascular bundles from which the fungus was isolated.

PLATE LIV

Fig. 1.—*Ascochyta clematidina:* Photomicrograph of a pycnidium from stained section of a leaf of *Clematis paniculata.*

Fig. 2.—*Ascochyta clematidina:* Culture growing on agar to which Ivory soap at the rate of 1 pound to 15 gallons of water was added, showing the oily film about the margin of the culture in which the crystals of stearic acid are found.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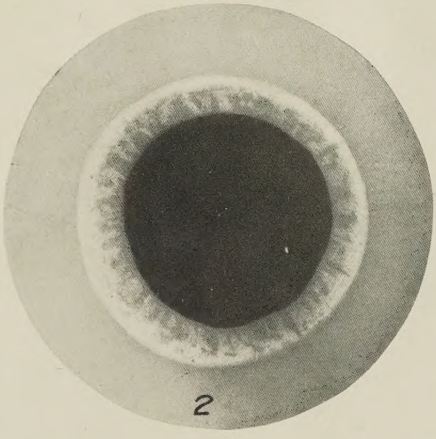
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